ACCESSION #: 9211230265
LICENSEE EVENT REPORT (LER)

FACILITY NAME: Oconee Nuclear Station, Unit 2 PAGE: 1 OF 40

DOCKET NUMBER: 05000270

TITLE: Loss of Off-site Power and Unit Trip Due to Management Deficiency,
Less Than Adequate Corrective Action Program
EVENT DATE: 10/19/92 LER #: 92-04-00 REPORT DATE: 11/18/92

OTHER FACILITIES INVOLVED: Oconee, Unit 1 DOCKET NO: 05000269
Oconee, Unit 3 05000287

OPERATING MODE: N POWER LEVEL: 100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR SECTION:
50.73(a)(2)(ii)(C)
50.73(a)(2)(iv)

LICENSEE CONTACT FOR THIS LER:
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COMPONENT FAILURE DESCRIPTION:
CAUSE: SYSTEM: COMPONENT: MANUFACTURER:
REPORTABLE NPRDS:

SUPPLEMENTAL REPORT EXPECTED: No

ABSTRACT:

On October 19, 1992, at 2121 hours, Oconee Unit 2 experienced a Loss of Offsite Power, a generator load rejection, and a trip from 100 % Full Power. A battery charger was placed in service without a connected battery. it produced excessive voltages which caused a series of spurious
breaker failure relay actuations, locking out both buses in the 230 KV Switchyard. The relays had been identified as susceptible to spurious operation due to excessive voltages in 1980 but were not modified. Also, during recovery actions, shutdown of one emergency generator, after the emergency start signal had been reset, resulted in the unanticipated trip of the operating emergency generator leading to a second loss of power on Oconee Unit 2. The root cause of the event was determined to be

Management
Deficiency, (Deficient Program, less than adequate corrective action). Corrective actions included several modifications, procedure changes, and equipment reviews.

END OF ABSTRACT

BACKGROUND

Each Oconee unit is provided with several sources of normal and backup electrical power. The Start-up and Stand-by Sources are part of the Emergency Power System [EIIS:EB] as described below.

The Normal source of power for an operating Oconee Unit is from the unit's generator via the Auxiliary Transformer (1T, 2T, or 3T). The Auxiliary Transformer provides 6900 V power [EIIS:EA] for operating Reactor Coolant Pumps (RCPs), and 4160 V power to two Main Feeder Buses (MFBs) for the rest of the no mal loads.

The Start-up source of power is from the 230 KV Switchyard (SWYD) [EIIS:FK] via the unit's Start-up transformer (CT1, CT2, or CT3), and
it also provides both 6900 V power for RCPs and 4160 V power to the MFBs.

The Stand-by source can receive power from the underground feeder from
Keowee Hydro (KH) Station [EIIS:EK], which serves the function of emergency diesel generators typically used at nuclear stations, via CT4 or from the Central Switchyard via CT5. The underground feeder and associated transformer (CT4) are sized to carry full Engineered Safeguards [EIIS:JE] loads of one Oconee unit plus the auxiliary loads
required for safe shutdown of the other two Oconee units. However, the Stand-by source only provides 4160 V power to the MFBs and cannot
provide 6900 V power for RCPs.

Each Oconee unit's power sources are monitored by the Emergency Power Switching Logic (EPSL) and the Main Feeder Bus Monitor Panels (MFBMP). EPSL will monitor the voltage available to the Normal Source, and will initiate a breaker trip to isolate the Normal Source if an undervoltage condition exists. It will then attempt to transfer to the Start-up
Source

by closing the Start-up breakers if voltage is available there. For "routine" events, such as a unit trip, this transfer is all that is necessary to provide uninterrupted power to station loads.

In the event that power is not available via the Start-up Source, due to a Loss of Off-site Power (LOOP), the MFBMP will initiate automatic actions to provide power. The Stand-by Bus is not normally energized, but, after a 20 second time delay, the MFBMP will automatically emergency start KH, and actuate EPSL to loadshed unnecessary loads, and connect one unit to energize the Stand-by Buses. After an additional 10 second time delay, EPSL will initiate Stand-by Breaker closure to energize the MFBs from the Stand-by

Buses.

In the event of a Loss of Coolant Accident (LOCA) concurrent with a LOOP, power is needed by the LOCA unit almost immediately. Therefore, Engineered Safeguards initiate an immediate KH emergency start, EPSL actuates loadshed and, after ten seconds, the Stand-by Breakers close to provide power to the MFB.

Per Technical Specifications (TS), offsite power must be available from the system grid via the Oconee 230 KV Switchyard. The SWYD (see Attachment 1) has two electrical buses and a number of circuit breakers that connect the generators with the transmission system. The buses provide junction points for the power exchange between generators and the system. The SWYD can receive power from the generator output transformers for Oconee Units 1 and 2, and Keowee Hydro Station. In addition, the SWYD can supply power to the Start-up transformers for Oconee Units 1, 2, and 3. The SWYD also connects to four pairs of 230 KV transmission lines (Jocassee, Dacus, Oconee, and Calhoun) and to the 525 KV SWYD which connects the Oconee Unit 3 generator to the 525 KV distribution system.

In the SWYD, Power Circuit Breakers (PCBs) control the flow of AC power

and
isolate any section that may be faulted. The SWYD is arranged in a breaker-and-a-half scheme, so called because three PCBs are used to connect
two circuits. The two SWYD buses are designated as the RED bus and the YELLOW bus. Each PCB is designated with a number as shown on Attachment 1.

Keowee Hydro Station consists of two hydroelectric generators [EIIS:GEN]; Air Circuit Breakers (ACBs) 1 through 8; the Main Step-up transformer; auxiliary power load centers 1X and 2X, and associated support equipment and auxiliaries. (See Attachment 2.)

The "overhead" emergency power path is from one KH unit, through the unit overhead generator breaker (ACB-1 or 2), the main step-up transformer, the
switchyard yellow bus, the applicable Oconee unit startup transformer (CT-1, 2, or 3), and the associated startup breakers (E1 and E2) to the main feeder buses. An External Grid Protective System monitors voltage and
frequency on the RED and YELLOW buses, and Degraded Grid System monitors the voltage at the startup transformers to detect a switchyard or grid disturbance. If voltage or frequency is degraded on both buses or an undervoltage condition exists on two of the three startup transformers simultaneously with an Engineered Safeguard signal on any Oconee unit, the
system initiates. it isolates the switchyard by tripping appropriate PCBs,
starts both KH units, and aligns the SWYD to distribute power from the appropriate KH unit to the

startup transformers via the YELLOW bus.

The "underground" emergency power path is from the second KH unit, through
the unit underground generator breaker (ACB-3 or 4), an underground feeder,
transformer CT-4, the CT-4 feeder breakers (SK-1 and SK-2), the standby buses (SBB), and unit standby breakers (S1 and S2) to the main feeder buses. This underground feeder is connected, at all times, to one KH generator on a predetermined basis and is energized along with CT-4 whenever the associated KH unit is in service.

Each KH unit is provided with its own automatic start equipment. Both

units undergo a simultaneous automatic start and run in standby on a loss of the grid, an engineered safeguards actuation on any of the three Oconee
Units, or an extended loss of voltage on any unit's main feeder buses. On
an emergency automatic start, the unit connected to the underground feeder
supplies that feeder while the other unit, remaining in standby, is available to supply the overhead path. If there is a grid disturbance, this unit is automatically connected to the Oconee SWYD YELLOW bus after switchyard isolation as described above. Therefore, in the event of a LOCA/LOOP or degradation of the grid, emergency power is available from either KH unit through the underground path and/or the overhead path.

Within KH, when one or both KH units are generating to the Duke system, auxiliary power is fed via the KH Main Step-up Transformer to the 1X and 2X load centers which serve KH Units 1 and 2, respectively, as shown on Attachment 2. When the KH units are shut down, auxiliary power is backfed
through the transformer from the SWYD. A backup source is available to each load center by automatically connecting to an underground feeder from
Oconee Unit 1. The feeder breakers to each load center are designed such that, on loss of normal power, the no mal feeder breaker (ACB-5 or 6) will
open and the back-up breaker (ACB-7 or 8) will immediately close. If power
is restored to the normal breaker for ten seconds, the back-up feeder breaker will open and the normal breaker will immediately reclose. An interlock will prevent normal operation of a KH unit if voltage is lost at
the main Step-up Transformer. However, the KH units are capable of operating for a limited period of time (estimated to be between 30 to 60 minutes) without auxiliary power and this trip is bypassed if an emergency
start signal is present.

Power can be made available to the standby power buses from one of the Lee Steam Station combustion turbines (CT). The power is provided through a 100 KV transmission line from the Lee CT's via the Central switchyard to Oconee's CT-5 transformer. If an emergency occurs that would require the use of this 100 KV line it can be isolated from the balance of the transmission system in

order to supply power to Oconee. One of the Lee CT's can be started and supply power within one hour. An alternate power alignment is from the Central Switchyard, which has been modified to include relaying for degraded grid protection. Use of Central Switchyard as an emergency power
source is allowed by the station's abnormal procedures as a last resort for
restoring power.

TS 3.7 requires both KH units and both power paths from KH to be operable.
One KH unit may be removed from service for 72 hours if the other KH unit is tied to the underground power path and is verified to be operable within
one hour. This is verified by starting the Keowee Unit and energizing the
Standby Bus. Both KH units may be inoperable for up to 72 hours for planned reasons if the standby buses are first energized from CT-5 transformer using the dedicated line from the Lee CT's. This last limiting
condition for operation is reduced to 24 hours if both KH units are inoperable for unplanned reasons and the Standby Bus is energized from a dedicated Lee CT within 1 hour.

The DC power system [EIIS:EJ] for the Oconee 230 KV SWYD is divided into two DC buses (SY-1 and SY-2), each supplied by a battery and an associated
battery charger (see Attachment 3). A spare charger can be connected to either DC bus to allow testing and maintenance of the installed charger. The buses can be connected to each other by closing a set of connecting breakers. Each of the two buses provide power for PCBs and associated protective relays located in the SWYD and the nearby relay house. The loads are divided such that the SY-1 bus provides power to all of the primary controls and relays for all of the PCBs. The SY-2 bus provides power to back-up relaying, including the Breaker Failure Relays for each PCB.

TS normally permit a single string or component of the 125 VDC power system
for the SWYD to be out of service for 24 hours. However, the NRC approved
a limited TS amendment to allow one battery and associated distribution center to be inoperable for 7 days due to the extended period of time required for a battery replacement modification.

EVENT DESCRIPTION

In 1989, a Station Problem Report was initiated which requested replacement and upgrade of the existing batteries in the 230 KV Switchyard (SWYD) at Oconee Nuclear Station. In December 1990, the associated Nuclear Station Modification (NSM) was initiated. In May, 1992, Duke Power Company submitted a request for a revision to Technical Specifications in order to extend a Limiting Condition for Operation (LCO) from 24 hours to 7 days. This would

allow one battery or associated DC distribution panel to be out of service long enough to replace the batteries in accordance with the NSM. In the submittal for this revision, Duke Power stated that, as part of compensatory action, the two DC buses would be tied together "whenever practical."

As part of the modification package, two implementation procedures were developed, one for each battery. During the development of these two procedures, it was decided that the preferred configuration of the two DC buses would be to maintain separation of the buses, and to use the associated battery charger as the only power supply to each bus as its battery was replaced. During this decision making process, personnel in Engineering and Operations were consulted and concurred. After review, procedure TN/5/A/2863/00/AL2 "Replace 230KV SWYD Batteries SY-2", was approved October 15, 1992.

During the period from October 6 until October 12, 1992, the SY-1 battery was replaced. During this time DC power was supplied to the SY-1 bus by the associated charger alone, without any incident.

On the evening of October 19, 1992, Oconee Units 1, 2, and 3 were all operating at 100% Full Power and Keowee Unit 1 was also generating to the system. Keowee Unit 2 was dedicated to the underground power path, with ACB-4 closed.

TN/5/A/2863/00/AL2 "Replace 230KV SWYD Batteries SY-2", was in progress. The procedure had reached a status where the breakers connecting SY-1 and SY-2 buses were closed and the breakers connecting the SY-2 battery and associated charger were open. The cables connecting the battery to the charger had been disconnected. Because the SY buses were connected, all three Oconee units were in an LCO.

The Unit 1 Supervisor (US1) went to the switchyard (SWYD) relay house with several electrical technicians to perform steps in the NSM procedure to reconnect the charger and separate the DC buses. In accordance with the procedure, US1 verified that DC voltage on the charger was reading 132.6 (0, +2) volts, then closed breakers to connect it to the SY-2 bus. At approximately 2121 hours, he opened the tie breakers which had connected the SY-1 bus to the SY-2 bus. US1 noted that SY-2 charger picked up load and was supplying approximately 20 amps.

Within the next several seconds many events occurred including a loss of switchyard, a trip of Oconee Unit 2, a normal trip of Keowee Hydro (KH) Unit 1, and emergency start of both KH units. Operator actions were taken in the

switchyard, the Oconee control rooms, and the Keowee control room. A detailed, integrated sequence of events is included as Attachment 4 for reference and each significant event is discussed below.

One of the electrical technicians with US1 reported that several seconds after the tie breakers were opened on SY-2 he heard several relays in the relay house actuate. Seconds later both the technician and US1 heard the sound of the main steam relief valves opening on one of the Oconee units.

They also reported that the output meter of the charger fell to zero, (which is expected because its source of power is Unit 2). Suspecting that his actions had affected the switchyard, US1 "backed out" of the procedure by reclosing the SY-1 to SY-2 tie breakers and opening the breaker from the SY-2 charger.

The Events Recorder (ER) [EIIS:IQ] for the SWYD showed numerous relay actuations and Power Circuit Breaker (PCB) trips. Bus lockout relays were . actuated on both buses. The overall result was that all PCBs connected directly to the RED and YELLOW buses tripped open, leaving only PCBs 11, 14, and 20 closed.

One result of these PCB trips, was that the RED and YELLOW buses were totally isolated, resulting in undervoltages being detected which actuated the External Grid Protection System. This system initiated a Switchyard Isolation signal designed to isolate the YELLOW bus, send an Emergency Start signal to both KH Units, then reclose PCBs to connect one KH unit to the Start-up transformers of all three Oconee units to provide emergency power. However, due to the YELLOW bus lockout, PCB-9 (connecting to KH) and PCBs 18, 27, and 30 (connecting to the Start-up transformers) could not close. This left all three Oconee Units without power available to their Start-up source.

As stated above, KH Unit 1 had been generating to the grid prior to the

SWYD isolation. Both PCBs 8 and 9 opened due to the SWYD relay actions, therefore, KH Unit 1 underwent a load rejection. However, at approximately the same time, the Emergency Start signal was received, which caused Keowee ACB-1 to open for approximately 6 seconds then reclose.

According to Keowee Operator A (KO A), he was in the turbine room when the event began. His first indication of the event was that he heard a loud "bang" and the overhead lights went out. The "bang" was apparently ACB-1 opening, which isolated KH auxiliary power load centers from the KH Unit 1 generator. He heard another "bang" moments later (ACB-1 reclosing) while he returned to the control room, where he immediately observed multiple flashing alarms. He failed to observe the specific alarm which indicated that an

Emergency Start signal had been received. He did note the meter that indicated that KH Unit 1 was operating with no load.

Thinking that KH Unit 1 was still generating to the grid and was undergoing a failure that might damage equipment, KO A operated the control switch to manually trip ACB-1, and observed that all AC power to KH auxiliaries was lost. This included power to statalarms for both units, the plant telephone, the KH ER, and the KH Operator Aid Computer (OAC) output printer. As a result, KO A lost normal communications with Oconee and access to much of the data he was accustomed to using for diagnosing problems and determining unit status.

At this point, KO A observed from meter indications that KH Unit 2 was starting and concluded that an Emergency Start had occurred. At some point in this sequence, a KH main transformer lockout relay was actuated. Due to the transformer lockout, he was unable to reclose ACB-1.

During this portion of the event, the KH auxiliary power breakers for load centers 1X and 2X should have transferred to the backup power feeder from Oconee Unit 1. However, these transfers apparently did not occur.

KH Unit 2 started and energized CT-4 via the underground path within approximately 20 seconds from the initiation of the Emergency Start signal.

The first alarm received by the Oconee Unit 2 ER was an alarm which indicated that the breaker failure relay actuated on either PCB-23 or 24 at 2121 hours. If it had been the PCB-23 relay, the expected result would have been a trip of breakers at the other end of the Calhoun White line, which did not occur. If it had been the PCB-24 relay, the expected results would have been activation of a YELLOW bus lockout and the trips of PCB-23, PCB-24, and all other PCBs connected to the YELLOW bus. Also, the Unit 2 generator would receive a lockout, which would, in turn, trip the reactor.
The Oconee OACs and ERs indicated that these results did occur.

N1 and N2 (Normal Source 4160 V breakers which supply power from the Oconee Unit 2 generator to auxiliary loads) opened. Because PCBs 26 and 27 had tripped, which isolated the Start-up Transformer (CT-2), E1 and E2 (Start-up Source breakers) were unable to provide power, resulting in a loss of power to both Unit 2 Main Feeder Buses.

The Main Feeder Bus Monitor Panels (MFBMPs) detect undervoltage on the Main Feeder Buses. If the undervoltage exists on both buses for 20 seconds, the MFBMP circuits actuate causing several automatic actions. One is the

generation of a KH Emergency Start Signal (in this case, the signal was already present from switchyard isolation). A second action is the actuation of the Emergency Power Switching Logic (EPSL) load shed and Stand-by Breaker closure logic. It also generates start signals to High Pressure Injection [EIIS:BG] pumps and Component Cooling [EIIS: CC] pumps to protect the Reactor Coolant Pump seals by providing seal injection and seal cooling. By design, after a one second time delay, the load shed circuit trips 4160 VAC breakers which provide non-essential loads on the affected Oconee unit. After an additional ten seconds, the Stand-by Bus breakers are allowed to close. The closure of the Stand-by Bus breakers, restored power to all essential components on Unit 2, approximately 33 seconds after the trip, and ended the first loss of power event.

In the shared Oconee Unit 1 and Unit 2 control room, the Control Room Supervisor (CRSRO) stated that he heard the sound of an ER printing out just prior to the receipt of numerous alarms. He observed that the control rod position indications showed that a trip had occurred and noted that normal room lighting had gone out on the Unit 2 side of the control room and backup lights had come on, indicating a loss of power. He obtained the Emergency Operating Procedure and began reading steps for the Reactor Operators (ROs) to verify proper post-trip automatic responses and to identify the unit status. Upon observation that the Main Feedwater [EIIS:SJ] Pumps had tripped (as expected following a loss of power), RO-A obtained the Abnormal Procedure for Loss of Main Feedwater. RO-B monitored the control board and responded to the CRSRO. After verifying that Unit 1 had not tripped and was relatively unaffected, RO-C (one of two ROs assigned to Unit 1) obtained the Unit 2 Abnormal Procedure for Loss of Power, and began performing actions within that procedure as directed by the CRSRO.

The Operations Shift Supervisor (OSS) and the Unit 3 Unit Supervisor (US3) were in the Unit 3 control room prior to the event. When the loss of the Unit 3 Start-up source was indicated by alarms and the sound of the Unit 2 Main Steam Relief valves was heard, they rapidly verified that Unit 3 was stable, then both OSS and US3 left Unit 3 and proceeded to Unit 1 & 2 control room to assist. Upon entering the Turbine Building, they observed the loss of Unit 2 lighting, which they recognized as being the result of a loss of power event. While still in the Turbine Building they heard a page from the control room announcing the trip and requesting OSS and the Shift Manager, who is also the Shift Technical Advisor, to report to the control room.

The Shift Manager arrived in the control room and monitored the plant stabilization.

US1 called the control room from the SWYD. He notified the personnel there of the probable relationship between his actions with the battery charger, SWYD events, and the unit trip. He was informed that the affected unit was Unit 2, and was requested to stand by at the SWYD in case action was needed to reset the various lockout relays located in the relay house.

The immediate post trip response of Unit 2 was nominal for a loss of power event. The Reactor Protective System [EIIS:JC] was actuated by the generator trip signal, the control rod drive breakers tripped as required and all control rods [EIIS:ROD] inserted into the core, shutting down the reactor.

The response of several systems was specifically affected due to the loss of power, The Reactor Coolant Pumps (RCPs) coasted to a stop. The Condenser Cooling Water (CCW) [EIIS: BS] system went into the gravity

flow
mode. Main Feedwater was lost due to loss of power to the Hotwell and Condensate Booster Pumps. The Motor Driven Emergency Feedwater [EIIS: BA]
Pumps (MDEFWPs) could not start.

The Turbine Driven Emergency Feedwater Pump (TDEFWP) started automatically.
Within a few seconds after start, the Emergency Feedwater flow dropped to zero for approximately 3 to 5 seconds, then returned. Due to the short duration, it was not observed by the operator. As the TDEFWP picked up flow again, power was restored and both MDEFWPs started. The control system for emergency feedwater began to fill the steam generators (SG) to establish natural circulation cooling of the core. At approximately 2125 hours, with all indications that both MDEFWPs were operating, RO-A shutdown
the TDEFWP as directed by the Loss of Main Feedwater Abnormal Procedure (AP).

Normal Reactor Coolant System (RCS) [EIIS:AB] operating temperatures are approximately 601F at the hot legs and 557F at the cold legs for an average
RCS temperature of 579F. After a normal trip, when RCPs continue to operate, the hot leg and cold leg temperatures converge at approximately 555F. In this case, the RCS hot leg and cold leg temperatures began to converge while the RCPs coasted down with a corresponding drop in RCS flow.
When emergency feedwater (EFDW) flow reached the SG, the hot leg an cold leg temperatures diverged, as expected, to create a density differential which forces flow through the core and steam generators in natural circulation. The temperature differential varied from a low of approximately 21F to a high of approximately 56F, stabilizing 30 minutes after.the trip at around 33F and slowly decreasing thereafter as decay heat
reduced. During this time the cold leg temperature decreased from 557F to
a low of 511F and stabilized at approximately 535F.

Normal RCS pressure is 2155 psig. Due to routine fluctuations it dropped to 2144 psig prior to the trip. As the RCS temperature dropped, the post-trip pressure dropped to 1921 psig approximately one and a half minutes after the trip. 2RC-1 (pressurizer spray control valve) did not control properly. It should have closed at 2155 psig but operator action was required to manually close it at 2145 psig. RCS pressure increased when power was restored and HPI flow was restored. Pressure reached a maximum of 2232 psig before stabilizing at approximately 2155 psig. Pressurizer (PZR) level decreased from about 220 inches prior to the trip to approximately 93 inches as the RCS temperature and pressure dropped. When power was restored and HPI flow was restored, PZR level returned to approximately 125 inches. As the system was being stabilized, PZR level dipped again, rose to a post-trip peak of 129 inches before being maintained at approximately 100 inches.

Steam generator levels dropped from 161/156 inches (steam generators 2A and 2B, respectively) before the trip to a minimum of 68/66 inches after the trip. They then filled and stabilized at approximately 241/236 inches. The set point for natural circulation is 240 inches. Steam pressures were approximately 900 psig before the trip. After the trip, pressures ranged from a high of 1124 psig, which is slightly higher than expected, to lows of 772 and 734 psig. The low pressures were the result of the EFDW flow rate as the steam generators filled to the 240 inch setpoint. This flow rate cooled both the RCS and the steam in the steam generator, thus reducing the steam pressure. When RO-A shut down the TDEFWP, the EFDW flow was reduced, the RCS cooldown rate stayed within limits, and the steam pressure stabilized. As the SG level setpoint was reached, the SG pressure was controlled at 900 psig.

The primary Instrument Air (IA) compressor is powered from the SWYD via PCB4, so it lost power when the SWYD RED bus lockout occurred. Additionally, one backup IA compressor is powered from Unit 2, but was load shed and could not automatically start. Two other backup compressors, powered from Unit 1, started and attempted to maintain pressure in the IA system. Alarms were received on Unit 1 and Unit 2 at approximately 2122 hours indicating low pressure in the IA system. Therefore RO-D (assigned to Unit 1) obtained and entered the AP for Loss of Instrument Air. In accordance with this procedure, he called the Unit 3 control room and had operators there dispatch a non-licensed operator to start a diesel power air compressor which is connected to the Instrument Air header. This resolved the immediate problem.

Approximately one to two minutes into the event, after power had been restored, the operators observed that Reactor Building Cooling Unit (RBCU)

[EIIS:VA] Fars A had not restarted. The operator attempted to restart it but it would not go into HIGH (normal) speed. It would run in LOW (emergency) speed.

At this point, in accordance with the Loss of Power AP, RO-C reset the Main
Feeder Bus Monitor Panel, which also reset the EPSL loadshed signal. This
allowed the operators to begin returning loadshed equipment to normal service.

At 2130 hours, US3 called the Operations staff duty person at home to notify him of the event. The duty person then initiated notification of various members of station management and staff of the event. The NRC site
resident inspector was also contacted. Several members of management and staff technical experts were called in to assist with the recovery.

At 2134 hours, the CCW system was realigned and CCW Pump A was started to terminate the gravity flow mode of operation. At this time a problem with
2CCW-24, Condenser 2C1 Outlet Valve, was observed and a work request initiated for investigation and repair.

At about this time, KO A contacted the Duke System Dispatcher via a dedicated dispatcher phone line, which was still in service. KO A requested that the dispatcher contact KO B, a member of the KH technical support staff, and have him come in. The Dispatcher was also able to tie in the Dispatcher phone in the Oconee Unit 1&2 control room so that KO A and US2 could talk to each other.

KO A told US2 that there were "problems" with the KH auxiliary power system, but it is not apparent that US2 understood that all auxiliary power
had been lost and that continued operation of KH Unit 2 was in jeopardy. US2 told KO A that Oconee Unit 2 was dependent on KH Unit 2 for power and for him (KO A) "not do anything to affect Unit 2 at this time." KO A stated
after the event that he understood this to mean take no action at all, so he waited for KO B to arrive. While waiting, he made a quick tour, using a flashlight, to assess the status of the equipment.

Upon notification that KH had "problems" with auxiliary power, OSS contacted the Dispatcher to consult about restoring the SWYD. The Loss of

Power AP is written such that it assumes that a SWYD isolation has occurred
due to real faults that need to be evaluated and isolated prior to restoring the affected breakers, buses, and transmission lines. Therefore,
up to this point, OSS had anticipated a lengthy check out of equipment to assure that the event was not due to a real fault. However, the Dispatcher
confined that he had no

indication of faults or breaker actuations outside the SWYD. with this information and a new urgency due to the status of KH, OSS reassessed the situation and decided, with the Dispatcher's concurrence, to go ahead and try to restore the SWYD.

At approximately 2150 hours, KO B arrived at the KH control room. KO A briefed him of the situation. The most immediate concern was the loss of auxiliary power, which affected the operation of KH by preventing make-up to the hydraulic oil accumulator tanks on each unit. These accumulators provide the oil to operate the governor and wicket gates to control turbine
speed, and, therefore, generator output. The normal operating level In the
accumulator is approximately 48 inches on a sight glass. When KO-B arrived, the level on both accumulators was between 4 to 8 inches.

KO B used the Dispatcher phone to talk to the Dispatcher and US2 at Oconee.
They decided to attempt to reset the KH main transformer lockout. At this
same time, it was decided to have the Dispatcher call Lee Steam Station to
start a combustion turbine and begin actions to establish the dedicated line from Lee.

At approximately 2158 hours, KO B reset the transformer lockout. This allowed ACB-1 to close automatically, which, in turn, allowed KH Unit 1, which had been running with no load, to energize the transformer. With voltage available, ACB-6, the normal power supply breaker to 2X loadcenter,
closed in, restoring auxiliary power to KH Unit 2.

At 2159 hours, the KH operators observed that 1X loadcenter for KH Unit 1 was locked out. They attempted to reset it but it would not reset.

At 2200 hours, US1 reset the RED and YELLOW bus lockouts for the SWYD.

At 2201 hours, the Dispatcher logged that he had told the Lee Steam Station operators to start up a combustion turbine for Oconee.

At 2206 hours, KO B determined that ACB-7, the backup supply breaker to 1X, had a local lockout. This was reset at the breaker. KO B returned to the KH control room and closed ACB-7. This restored auxiliary power to KH Unit 1.

At 2213 hours, Operations closed PCB-10. This re-energized the RED bus, clearing the undervoltage condition on the bus. As a result, PCBs 7, 13, 16, 19, and 22 were able to automatically reclose.

At 2214 hours, Operations attempted to close PCB-26 to restore power to the

Unit 2 Start-tip Transformer from the RED bus. It cycled but tripped back out due to the continued Switchyard Isolate signal. However, due to this movement, PCB-26 momentarily interrupted the Switchyard Isolate Complete logic, which provides a close permissive signal to PCB-9. This allowed the anti-pump logic to reset and PCB-9 closed automatically at 2214 hours, connecting KH Unit 1 to the YELLOW bus, restoring voltage there.

Operators then reset the Switchyard Isolate signal. This made it possible to restore the Start-up Source for the Oconee units by aligning the Start-up transformers to either the RED or YELLOW bus. OSS had directed the operators to focus on restoring the Start-up source to Unit 2, so they manually closed PCB-26, which supplied voltage to the Unit 2 Start-up transformer from the RED bus, at 2218 hours.

At 2221 hours, the dedicated line from Lee was available with the combustion turbine on-line.

OSS was concerned about the potential for inadvertent or automatic connection of the RED bus, energized from the grid, to the YELLOW bus,

energized from KH Unit 1, while the two sources were not synchronized. Rather than closing PCBs to restore power to the Start-up Transformers for
Units 1 and 3, the decision was made to shutdown KH Unit 1 to remove voltage from the YELLOW bus, then re-power the bus by closing a PCB-to reconnect the YELLOW bus to the RED bus.

Some of the management and staff personnel who had been notified earlier began arriving and were briefed on the situation. One of the first to arrive was the Superintendent of Operations (SOPS). The action plan for restoring the SWYD was discussed and SOPS concurred with the plan.

OSS reviewed the plant status and declared an Unusual Event at 2225 hours.
Appropriate notifications were made by approximately 2237 hours.

In order to shut down KH Unit 1, it was necessary to reset the emergency start signal. Since this signal goes to both KH units, resetting it would
affect both units. This signal was reset at 2242 hours.

The KH operators were still in the process of evaluating and trying to correct the problem with ACB-5, the Unit 1 normal auxiliary power breaker.
At 2247 hours, they tried to reclose ACB-5 and inadvertently tripped ACB-7
and locked out 1X again. The lockouts were reset and ACB-7 was reclosed to restore auxiliary power to Unit 1.

At 2251 hours, OSS requested that KH Unit 1 be shutdown. This was done but
some of the results were unexpected. The YELLOW bus de-energized as expected, but KH Unit 2 tripped also. This was due to protective logic which monitors the voltage on the Main Step-up Transformer. Since there was an undervoltage condition with KH unit 1 no longer supplying power, and
no Emergency Start signal, this logic assumed that KH Unit 2 was trying to
generate to the grid with no auxiliaries and no output, and tripped KH Unit
2. This trip de-energized the Underground feeder and, therefore, the Standby buses and the Unit 2 Main Feeder Buses.

The EPSL contains circuitry to retransfer from the Stand-by Buses to the

Start-up Source if necessary. However, this portion of the circuit is only active if a load shed signal is present. Since that signal had been reset previously, the logic now required that the MFBMP actuate, which included a 20 second time delay. At the end of that time, the MFBMP initiated another KH Emergency Start and, after an additional second, another load shed. Another ten second time delay was included in the retransfer logic so that it took a total of approximately 31 seconds for the associated time delay relays to time out. At the end of this delay time, the Stand-by Breakers tripped open and the Start-up Breakers closed as designed to restore power.

KH Unit 1 responded to the new emergency start signal as expected. it restarted, but did not close into the YELLOW bus because PCB-26 was out of position so there was no SWYD Isolate Complete permissive to reclose ACB-1.
Since the RED bus did not have an undervoltage, there was no SWYD Isolate Initiation signal to cause PCB-26 to reposition itself.

KH Unit 2 did not respond as desired. After the trip, it had begun to slow down but the emergency start signal caused it to restart prior to resetting a speed switch in the field breaker anti-pump circuit. This speed switch and the anti-pump circuit prevented the field from energizing and, therefore, kept the generator from functioning.

Again, while power was off, the MDEFWPs and HPI pump B ceased to provide flow. The TDEFWP was manually re-started and provided EFDW flow. HPI A pump received an auto start signal, but could not provide flow without power. When power was restored, the TDEFWP and HPI A pump were secured. Also, the Unit 2 CCW system had re-aligned for gravity flow and had to be restored to the normal lineup and a CCW pump restarted. Plant parameters such as RCS temperature, pressure, and inventory were temporarily affected but remained within normal limits and were promptly restored when power was restored.

Shortly after power was restored, additional staff personnel arrived on site, including technical experts on the systems involved. They were briefed and contributed their ideas as to appropriate actions/methods to use to restore the SWYD to normal,

The group was divided into two teams. One made plans for recovery of the YELLOW bus. The second was assigned to review and investigate the sequence of events thus far to make sure that the event and current equipment status was adequately understood.

On October 20, 1992, at 0018 hours, KH Units 1 and 2 were shutdown.

By 0024 hours, KH Unit 2 had slowed down enough to reset the speed switch in the field flashing circuit, and had been restarted and realigned to CT-4.

At 0041 hours, PCB-8 was closed, re-energizing the YELLOW bus from the RED bus and the Duke system.

Between 0048 and 0057 hours, Operations closed PCBs 4, 18, 27, 30, 21, 17, 28, 12 and 15 to restore the SWYD to its normal alignment. This restored power to the Start-up Sources for Units 1 and 3.

At 0114 hours, the first reactor coolant pump was restarted. This reestablished forced cooling of the core and ended the natural circulation cooling mode. The other pumps were subsequently restarted, with the last one being started at 0229 hours.

At 0125 hours, Operations notified Security that the Standby Shutdown Facility was in a Degrade condition due to loss of normal power, which is fed from Unit 2. The loss of power had occurred at 2121 hours when Unit 2 lost power the first time.

At 0344 hours, the Unusual Event was terminated.

Power was restored to the SSF and the Degrade mode was exited at 0415 hours.

Duke Power activated a Significant Event Investigation Team (SEIT) of personnel from the General Office, Oconee Site, and INPO. The NRC activated an Augmented Inspection Team. These teams assembled at the Oconee Site during the day on October 20, 1992.

Due to the problems with the auxiliary power at KH, the decision was made to temporarily maintain the dedicated line from Lee. Oconee was in a 72 hour

LCO due to tie configuration of the KH auxiliary power breakers. After discussions with the NRC, it was concluded that it was acceptable to maintain KH in standby with auxiliary power being fed from Oconee via CX transformer (from ACB-7 or 8) to whichever unit was connected to the underground path. The other KH unit would be aligned to receive auxiliary power via the main step-up transformer (from ACB-5 or 6). The transfer logic would be placed in manual until the automatic transfer circuits could be modified. At 2245 hours on October 22, 1992, this LCO was exited after appropriate procedures had been implemented to specify this alignment. At 2302 hours, on October 22, 1992, the combustion turbine at Lee was secured.

Subsequent investigation revealed that the SY-2 charger did not maintain bus voltage at approximately 130 VDC as expected. When tested using test instrumentation rather than the built-in output voltage meter, a series of rapid voltage swings occurred such that its voltage output exceeded 200 VDC. It was observed that the output voltage meter did not indicate the full magnitude of these swings as the seen by the test equipment. The vendor manual for the battery charger provides some specifications for current and voltage stability while connected to a battery, but no data is given for operation without a battery. No specific statement prohibits operation without a connected battery, but the setup instructions call for connecting a battery, and wording indicates that connection to a battery is assumed.

The charger vendor was consulted and stated that the chargers were not intended to be used without a battery in the circuit. Without a battery, the vendor expected the output voltage to vary, although the observed magnitude of the variation on SY-2 was "more than expected."

A review of the Preventive Maintenance procedure for this device indicated that it is checked in normal service with the battery and prevailing system load on the output. Also, the PM is performed using only the installed output voltage and current meters. Additional diagnostic testing and

inspections have been performed on the SY-2 charger, subsequent to the event. The testing indicates that the charger is not operating properly, but no specific defective component has been identified at the time of this
report. This testing will continue in an attempt to identify the cause.

The observed voltage swings exceeded the ratings of several relays connected to the SY-2 bus, including the breaker failure relays for all PCBs in the SWYD. The investigation also revealed that, in 1980, the vendor of the breaker failure relays had sent out "Product Reliability Letters" stating that these relays could actuate spuriously if exposed to a 200 VDC differential for greater than 2 milliseconds. The letters also contained

directions for a field change to correct the problem. Although the Duke personnel reviewing the letters recommended making the changes, the relays
in the Oconee SWYD were not modified.

Tests were performed where a breaker failure relay was connected to SY-2 charger with additional loads to simulate the conditions seen during the event. Test equipment showed that the relay actuated every time the charger output voltage went above 200 volts. The relay was then modified per instructions in the vendor's letter and the test was repeated. The modified relay did not actuate, even though the charger output voltage continued to swing above 200 volts. As a result of this test, the rest of
the breaker failure relays in the SWYD were modified prior to Unit 2 restart.

This investigation also noted that a similar event had occurred at Vermont
Yankee (VY) on April 23, 1991. The VY event had also involved operation with one switchyard DC bus powered by a battery charger while isolated from
the battery, inadequate voltage control by the charger partially due to failed components, and activation of breaker failure relays due to voltage
surges associated with establishing that battery configuration. This event
was evaluated per the Duke Power Operating Experience Program. The evaluations with respect to Oconee concluded, in part, that, due to differences in the breaker failure relay circuits, the relays in service
at Oconee were less susceptible to voltage spikes than those at vy, that

procedures did not permit simultaneous cross-connection of the spare battery charger to both DC buses (a factor at VY), and that an LCO limited
the time the two buses could be connected. The evaluations also addressed
the adequacy of general maintenance activities in the switchyard, but did not address periodic maintenance of the battery chargers, which was a specific item addressed in the report on the VY event.

As a precautionary measure, PCB-23 and PCB-24, were tested prior to Unit 2 restart to assure that no real faults existed on either breaker. These breakers were selected because the initial trip signal indicated by the Unit 2 ER came from them.

The KH computer receives AC power from the KH batteries via an inverter. Investigation revealed that the KH computer was provided with an AC outlet
to be used by the printer. However, at some point in the past, the KH computer printer had been replaced with a newer model. When this replacement occurred, the printer was also relocated. The new location was
closer to a wall outlet powered from KH Auxiliary power than it was to the
outlet on the computer, therefore it was plugged into the wall outlet. This made the printer vulnerable to a loss of auxiliary power. As a result
of this event,

it has now been reconnected to the computer outlet.

A significant effort was made to determine the causes of the problems with
the KH auxiliary power breakers. On the 1X (KH Unit 1) bus, it was concluded that ACBs 5 and 7 failed to transfer properly due to a mis-actuation of a breaker actuator device. This resulted in a Lockout of
the 1X bus, and ACBs 5 and 7.

Also, on the 1X bus, the auto throwover circuit, which transfers between sources, was not functioning properly. An intermediate relay (Westinghouse
Model MG-6) contact that drives the timing relay was not conducting, therefore the timer was not operating. As a result, the retransfer circuit

would be actuated with no time delay. However, this problem had little or no effect on operation during this event. MG-6 relays are used in many applications throughout Oconee Nuclear Station and at Keowee. An MG-6 relay problem discovered on September 29, 1992, involving a mechanical failure which made Keowee ACB-2 inoperable, resulted in LER 269/92-14.

On the 2X bus, throughout this event, KH Unit 2 auxiliary power transferred successfully to ACB-6 whenever it was energized. However, it was concluded that, when power was lost to ACB-6 from the main transformer, ACB-8 failed to close due to either dirty contacts on a model MG-6 intermediate relay activated by an undervoltage relay, or a stuck "X" relay. "X" relays are the anti-pump relays used in Westinghouse type DB breakers. The anti-pump circuitry allows the breaker to receive only one close signal. This prevents the breaker from cycling back and forth between closed and tripped on a trip signal.

In addition, testing and inspection showed that the retransfer logic was wired in accordance with a wiring diagram which was in conflict with the circuit schematic diagram. A ten second time delay relay was wired such that the bus was dead for ten seconds during retransfer from ACB-8 to ACB-6. However, this problem also had no effect on operation during this event.

Subsequent to this event, KO-B has reviewed the design of the hydraulic oil accumulator and has determined that, after oil level has dropped off scale, a float valve operates to seal off the supply line to the turbine speed control governor. When level is lost, the valve should close and "lock-in" the existing speed and load. Therefore, the affected KH unit could continue to operate as long as there is no significant change in load.

During the loss of power, a personnel injury occurred. A Radiation Protection technician was in the process of establishing backup power to

sampling equipment which had lost power due to the loadshed on the reduced lighting, the technician hit his head on a welding receptacle and received a cut. He was transported to a nearby hospital for examination and treatment. He returned to work after the examination. The cut did not require stitches and contamination was not an issue. Site industrial Safety personnel classified this as a non-recordable minor injury.

Several items were identified by the post trip review as requiring maintenance prior to restarting the unit.

RBCU 2A fan did not restart in high speed when power was restored. This was investigated per WR 38187C. High and Low speed contactors were found to be pitted and burned on the respective half-side to each contact, indicating misalignment. These contactors were replaced and contact alignment verified. A functional test demonstrated proper operation. Current readings dropped 2 to 4 amps.

2CCW-24 (Condenser outlet valve in the Condenser Cooling Water system) did not reclose when the CCW system was restored to normal. This was investigated per WR 38186C. The I&E technicians found a 1 inch air line supplying the valve pulled out of the ferrule of a fitting. The line was repaired.

The momentary loss of EFDW low from the TDEFWP was investigated by System Engineering. The investigation found an accumulation of water
in the Auxiliary Steam supply line to the TDEFWP turbine. The cause was thought to be a faulty steam trap. A Problem Investigation Report
was generated to address the root cause and recommend long term action. Site Engineering personnel have concluded that this is not an operability question in regards to potential turbine damage.

CONCLUSIONS

The root cause of the trip of Oconee Unit 2 event is considered to be Management Deficiency, (less than adequate policy) due to a less than adequate corrective action program, for reasons described below.

Three specific factors combined to produce this event. First, the breaker
failure relay zener diodes would pass a spurious signal when subjected to greater than 200 VDC for 2 milliseconds or longer. Second, the 230 KV Switchyard DC power system was being operated with the battery isolated from the SY-2 bus and with the battery charger as the only source of

voltage. Third, the SY-2 battery charger, when operated in this configuration, produced an output voltage which varied from approximately 70 to over 200 VDC.

The problem with the breaker failure relay design was identified and communicated to Duke Power in 1980. Duke Power personnel reviewed the notice and recommended corrective action be taken. However, the problem was not corrected on the relays in the Oconee 230 KV Switchyard. Due to the time elapsed since the evaluation and the lack of definitive documentation, it cannot be determined if the failure to correct this problem was due to a subsequent technical or management decision or due to
a failure to follow-up on the recommendation.

The Operating Experience Program (OEP) review by Duke Power for the Vermont
Yankee (VY) April 23, 1991, loss of off-site power event provided a second
opportunity to discover the problem. The actuation of breaker failure relays due to voltage surges in the DC power system was a causal factor in
VY event. However, the relay models involved were similar but not exactly
the same. The zener diode involved in the VY event does not exist in the equivalent circuit in the model used at Oconee. As a result, the OEP review of the VY event concluded that the equivalent portion of the circuit
would not fail the same way. The OEP review did not discover that a different circuit was subject to the same failure mode, with the same result: actuation of the relay.

If the breaker failure relay problem had been corrected, this event would not have occurred. Conversely, while relays with the problem design were in place, ground faults or lightning strikes could have caused a similar event at any time by producing voltage surges through the DC bus and actuating the breaker failure relays.

The DC system is designed to be at approximately 125 VDC. It was not

anticipated that it should operate at 200 VDC. Few, if any, of the connected relays are rated for exposure to 200 VDC. However, a review of these relays indicates that none of the other relays should have failed or
spuriously actuated if the breaker failure relays had not actuated first.

Therefore, exposure to this high voltage is only a problem if the breaker failure relays are not modified.

The other two causal factors (operation of a battery charger as a source without a battery and the fact that the charger voltage swings were excessive, indicating a defective component) were also causal factors in the VY event. The OEP review of the event at VY failed to address the issue of use of the battery charger connected to the load without a battery. It also failed to adequately address the issue of inadequate battery charger maintenance. As a result, Oconee personnel were not adequately aware of these aspects of that event and did not take appropriate action to prevent similar problems from occurring at Oconee. Correction of either of these factors would have prevented this specific event.

Many of the subsequent problems were known problems with corrective actions
in various stages of implementation. Several of these corrective actions involved routine upgrades to replace aging and/or obsolete equipment. Other actions were considered more urgent and had higher priorities and significant management attention. It is concluded that the scope and schedule for these planned corrective actions were reasonable. However, these corrective actions were not implemented promptly enough to prevent the known problems from affecting this event. These include:

1. Wiring at Keowee Hydro (KH) not per design drawings. Inspections to determine and evaluate deviations were in progress.

2. "X" relays failing to reset properly. One upgrade modification was completed on both KH units, on October 2, 1991. After KH Hydro Unit 1 was successfully started approximately 100 times, three additional "X" relay failures occurred between January 29 and February 20, 1992, A second modification had been performed on KH Unit 1, and was pending on KH Unit 2. It had been delayed to correct to problems encountered during the KH Unit 1 installation.

3. Speed switch in the KH Field circuit. This was being resolved by the "X" relay modification.

4. MG-6 relay problems had been discovered on September 29, 1992. Inspections were in progress.

5. Loss of normal telephone communication at KH. Modification was

being designed.

6. Switchyard battery chargers had been identified as obsolete and were scheduled to be replaced by battery eliminators.

7. Events recorders for the Oconee units and 230 KV switchyard were scheduled for upgrade.

Several problems/concerns became apparent due to this event.

1. Operator response was less than adequate. Specifically, KH Operator A (KO-A) performed an action which could have interfered with the safety function of KH Unit 1 by manually tripping ACB-1. Also, he failed to. take timely action to restore auxiliary power to both KH units. These were inappropriate actions arising from Human Factors Deficiencies related to training, procedural guidance, and habit intrusion.

2. Procedural guidance was less than adequate in several areas indicated below.

One problem was that procedures did not provide sufficient instructions for verification of proper operation of the KH unit providing emergency power. In the absence of a KH emergency procedure, this guidance should have been in the Oconee Loss Of Power Abnormal Procedure (AP).

The AP also lacked adequate guidance for recovering from a SWYD isolation. This led to KH Unit 2 subsequently tripping unexpectedly at 2252 hours. In this condition, no power would have been available automatically to Units 1 and 3 if either of them had tripped without an Engineering Safeguards actuation. Operators would have had to take manual action to connect to a power source (either LEE or the RED bus). This mode continued until 0018 hours.

Also, guidance was less than adequate in relation to the operability of the Standby Shutdown Facility (SSF). A degrade mode was declared at 0125 hours, on October 20th, retroactive to 2121 hours on October 19th. The principle concern was the status of the SSF battery. No guidance was included in the Loss of Power AP to declare this condition earlier, nor was a measurable criteria such as battery voltage provided. As a result, the personnel involved elected to conservatively make the declaration retroactive.

4. The vendor manual for the battery charger provides some specifications for current and voltage stability while connected to a battery, but no data is given for operation without a battery. No one consulted the manufacturer on this subject prior to the event. The vendor stated after the event that voltage swings of undetermined magnitude are expected in this mode.

Guidance not to use battery chargers without a connected battery is not specifically stated in the manufacturer's manuals and was not generally known at Oconee. This indicates potential training and/or communication deficiencies.

5. A concern was raised with respect to the appropriateness, with respect to single failure, of having certain loads (such as ALL breaker failure relays) on specific DC buses. Additionally, concerns were raised as to the appropriateness of having specific loads, such as the Keowee control room alarms, powered by auxiliary AC power rather than by some other source. NRC IE Bulletin 79-27, "Loss of Non-class 1E Instrumentation and control power system bus during operation" contains generic guidance, but has not been used to assess the Keowee and Switchyard systems.

A review of loss of power and reactor trip events at Oconee indicates that this event is not recurring.

The Breaker Failure Relays used in the SWYD are Westinghouse type SBFU styles 203C552A08, 203C552A21, 203C552A32, and 204C179A19. The SY-2 battery charger is an Exide Model USF 130-3-50. These items are currently
not identified as NPRDS reportable.

There were no excessive exposures, or releases of radioactive materials associated with this event.

CORRECTIVE ACTIONS

Immediate

1. The SY-2 bus was reconnected to the SY-1 bus and the SY-2 charger was removed from service.

2. Oconee Operators performed actions as directed in appropriate

procedures to stabilize Unit 2 at hot shutdown following the trip.

3. Lee Steam Station started a combustion turbine and the dedicated transmission line to Oconee was established.

4. KH personnel reset lockouts and restored power to KH auxiliaries.

5. The Oconee Switchyard was restored to normal status.

Subsequent

1. The modification procedure was revised to maintain SY-1 and SY-2 tied together and powered from SY-1 for the rest of the battery replacement.

2. The breaker failure relays in the switchyard were modified per vendor instructions. Similar breaker failure relays in the switchyard at Duke Power's McGuire Nuclear Station were also modified.

3. Other solid state equipment supplied by SY-2 were inspected for damage due to exposure to voltages higher than the system design. No damage was discovered.

4. Other Oconee procedures were reviewed, and precautions added where appropriate, to avoid use of a battery charger connected to a load without the battery in the circuit.

5. Indicating lights were installed on the KH control panels to provide direct indication of an emergency start signal. These lights are powered from the KH batteries and are independent of the KH Auxiliary AC power which provides power for the KH Statalarm system.

6. The KH computer printer has been reconnected to the computer power supply.

7. An Abnormal Procedure was issued to provide guidance for the KH operators following an emergency start. This included provisions for verifying proper operation of the KH units and corrective actions to restore or compensate for unexpected equipment response. The procedure also requires that any "abnormalities"

in the operation of the Keowee Units during an emergency be communicated immediately to the Oconee Control Room.

8. Duke Power management has revised the organizational structure such that KH Station is now part of the Nuclear Generation Department rather than the Hydro department. KH personnel will now report to the Oconee Site Vice President.

9. A dedicated "ringdown" phone was installed to connect KH control room to the Oconee control room.

10. Procedures were revised to temporarily maintain 1X and 2X switchgear in manual to prevent automatic transfers.

11. A review of maintenance history for the last three years and interviews with KH personnel were conducted to identity any other recurring problems. None were found.

12. A special test, TT/0/A/0620/02,"Keowee Hydro Load Rejection Test," was performed to confirm the proper response of KH to a simulated switchyard isolation signal when aligned to the grid.

13. A modification was made to the KH Circuitry so that the units will no longer trip due to undervoltage on the main step-up transformer. This interlock was moved in the circuitry such that it must be satisfied to enable a normal start, but will neither prevent an emergency start nor trip a running unit.

14. Dedicated flashlights were provided in the KH control room pending the assessment and resolution of permanent emergency lighting needs.

15. As an interim measure, Oconee Licensed Reactor Operators have been assigned to man KH and work with the KH operators. The purpose is to share Oconee's operating practices and standards with the Keowee Operators by utilizing the experience Reactor Operators have in control room and plant operations.

Planned

1. The adequacy of KH and Oconee operator and staff knowledge of KH design will be assessed. Appropriate training will be provided as needed to meet expectations.

2. A dedicated emergency radio (battery powered) will be provided for communications from the KH control room to the Oconee control room. This will require an antenna system to be installed at KH.

3. An upgraded phone cable will be installed between the Oconee site phone system and KH.

4. Improvements to the Oconee Loss of Power Abnormal Procedure will include guidance for recovery of off-site power sources. These will assure that recovery actions do not result in the unexpected loss of a KH unit.

5. Emergency lighting needs will be assessed for KH and any discrepancies identified will be resolved appropriately.

6. A modification will be implemented to preclude the transfer problem that was experienced during the event.

7. The pending modification to the X-relay circuit to change the mechanical anti-pump logic to an electrical logic will be implemented. This modification will also remove the speed switch logic which prevented KH Unit 2 from providing power after the second emergency start.

8. A planned corrective action from LER 269/92-14 is to develop a program to address the on-going reliability of all model MG-6 relays in safety related applications. This program is still under development.

9. A review will be performed to identify and implement improvements in surveillance testing to verify proper performance of the Keowee auxiliary power system transfer logic.

10. The testing requirements specified by Test Acceptance Criteria sheets referenced in the design basis document for KH emergency power will be reviewed to identify and evaluate any other surveillance testing deficiencies.

11. A station modification will be implemented to replace the switchyard sequence of events recorder with a newer model with enhanced capabilities.

12. The KH auxiliary power systems and the 230 KV switchyard 125 VDC

power system will be assessed in accordance with NRC Bulletin 7927 (or any appropriate guidance which may have superseded Bulletin 79-27).

13. The Operating Experience Program will be reviewed for enhancements to improve both the program and the periodic assessments of program effectiveness.

14. Site Engineering will determine the appropriate document (procedure, directive, etc.) to contain guidance to assure that "lessons learned" are available for review and reference in the preparation and review of Nuclear Station Modification implementation procedures (and/or other temporary procedures as appropriate). This will specifically address guidance on proper operation of battery chargers.

15. Testing will continue in order to identify problems with SY-2 charger and to verify operability of SY-1 and SY-S battery chargers.

SAFETY ANALYSIS

The high voltage from the battery charger and the unexpected interaction with the breaker failure relays provided the initiator to enter this design basis scenario and represents a single failure mode for the overhead path.

The Final Safety Analysis Report (FSAR) section 15.8 addresses loss of power scenarios. During this event Oconee Unit 2 experienced a loss of load condition, caused by separation of the unit from the transmission system and two momentary losses of all system and unit power.

The FSAR analysis shows that natural circulation of the reactor coolant system, turbine driven emergency feedwater system, condenser circulating water gravity induced flow, and gravity insertion of the control rods [EIIS:ROD] are among the design features provided to ensure the removal of decay heat for the reactor coolant system for the time power is not available. Furthermore, the analysis shows that, even without the emergency feedwater system, a total of 106 minutes will elapse before boiloff will start to uncover the core. With emergency feedwater available, calculations indicate an Oconee unit can withstand approximately six hours without electrical power before reactor coolant pump seal leakage will reduce inventory and begin to uncover the core.

In this event, power was lost to Oconee Unit 2 for two occasions of approximately 31 seconds each. During the first loss of power, the cont rods inserted into the core to shutdown the reactor and maintain it subcritical. During both losses, emergency feedwater, Condenser Cooling Water gravity flow, and natural circulation in the RCS all functioned and removed decay heat as designed. All operating parameters remained within anticipated limits while in this mode.

The emergency power systems generally performed as expected to restore power after the first loss of power. The loss of the overhead path due to the YELLOW bus lockout essentially constituted a design scenario single failure. The action of the KH operator to trip ACB-1, potentially defeating the safety function of KH Unit 1, is significant in that it provides one mode of failure of a safety train.

Even though power was not available from the switchyard, it was available from the underground path. The unsuccessful transfers to auxiliary power at KH are significant in that they provided potential common mode failures which could possibly have resulted in the loss of both KH trains, and, therefore, all automatic emergency power. Specifically, in this event, the operating KH unit could have been lost due to these failures. During this event KH Unit 1 operated 51 minutes without auxiliary power. KH Unit 2 operated 37 minutes without auxiliary power.

Backup power from Central Switchyard was available and could have been aligned within minutes if needed. The dedicated line from a Lee gas turbine was made available one hour after the start of the event, and within 31 minutes of the time it was requested.

When Keowee (KH) Unit 1 was shutdown and KH Unit 2 was unexpectedly tripped as a result, the emergency power system did not function as anticipated.

The action of the speed switch in the anti-pump circuit prevented KH Unit 2 from being able to perform its safety function. It also represents a single failure mode for one unit. Prior to modification of KH Unit 1, the speed switch design would have represented a potential single mode failure for both KH units.

KH Unit 1 was unavailable due to the abnormal switchyard configuration which, essentially, defeated the External Grid Protective System. However, a path from the RED bus had been established prior to shutting down KH Unit 1 and the Emergency Power Switching Logic (EPSL) automatically re-established power by connecting to that source. The backup source from Lee was still

available.

Therefore, at no time during the two lOss of power events was there less than two backup power sources available by manual action within minutes.

Oconee Units 1 and 3 were also affected by this event. The RED and YELLOW bus lockouts took the Start-up Source out of service on both units, therefore placing them within a Limiting Condition for Operation (LCO). While KH Unit 2 was out of service due to the anti-pump circuit, Oconee Unit 1 and 3 did not have an automatic source of power if one of them experienced a unit trip. However, if needed, power could have been manually restored by connecting the RED bus to the Start-up Source or by connecting Lee to the Stand-by bus. Therefore, those units also had two sources of backup power.

In the event of a LOCA on one of these units, power would have been available automatically from KH Unit 1 due to action of the Degraded Grid Protection circuits.

FSAR 15.14.3.3.6 assumes 33 seconds for the power outage after a LOOP prior to restoration of power from KH via Transformer CT4 and an additional 15 seconds for the operation of pumps and valves to establish system flow. In the remote event that a LOCA had occurred on one of the other Oconee

units and an additional failure prevented the automatic restoration of power to the affected unit, the emergency core coolant flow would have been
delayed beyond what was assumed in the accident analysis. If this happens,
fuel damage could occur which will result in a radioactive release to the containment building. The FSAR states that without Reactor Building Spray
[EIIS:BE] and Reactor Building Cooling Systems the reactor building pressure would not exceed the design pressure for the containment following
the LOCA. Given the 60 minute time frame to restore power, it is expected
that the reactor building leak rate would not exceed the LOCA analysis rate, but dose rates may be higher due to a loss of filtered ventilation until power is restored. A design containment response evaluation has shown that equipment qualification conditions would not be exceeded in under two hours for the expected temperature and pressure resulting from this event. Therefore, reactor building equipment would be operable when unit power is restored.

The Standby Shutdown Facility (SSF) is a separate seismically qualified building which houses the systems and components necessary to provide an alternate and independent means to achieve and maintain hot shutdown conditions for one or more of the three Oconee Units. The SSF was designed
to resolve the safe shutdown requirement for fire protection, turbine building flooding, and physical security. The SSF has the capability of

maintaining hot shutdown conditions on all three units for approximately three days following a loss of normal AC power.

However, during this event, an additional concern arose because power was interrupted to the SSF for a significant period of time. Without power to
the battery chargers in the SSF, the potential existed that the main SSF battery might have been drained below the point of operability. This raised the concern that the SSF might not be available if needed. However,
the SSF is equipped with a spare battery which could have been aligned and
used if needed.

A precursor study has been performed to provide a quantitative estimate

of
the significance of this event in terms of core damage likelihood. The conditional probability estimated for a precursor is useful in ranking an event because it provides an estimate of the measure of protection against
core damage remaining once the observed failures have occurred. The Oconee
annual average core damage frequency estimated by the Oconee Probabilistic
Risk Assessment study is 1.8E-5 events per year for internal event initiators and 9.2E-5 for external event initiators, combining for a total
of 1.1E-4 events per year. The conditional core damage probability for this event has been estimated to be 2.0E-5. Therefore, it is estimated that core damage would occur in only one of 50,000 similar events. Failures and potential equipment degradation occurring during this event which are significant include: the loss of off-site power initiating event,
the failure of the KH Auxiliary Power system, potential SSF battery depletion, and Emergency Feedwater turbine-driven pump starting problems.

Oconee has features which tend to decrease the significance of this event which might not be available to many other plants. These include the dedicated 100 KV path from the Central Switchyard and Lee combustion turbines, the SSF and its independent power source, and the ability to cross-connect power and emergency feedwater from the other units. Also the
quick recovery of off-site power to the CT-2 start-up transformer helped to mitigate the significance of this event.

There were no releases of radioactive materials or excessive radiation exposures associated with this event.

The health and safety of the public was not impacted by this event.

Figure "Attachment 1, Emergency Power Distribution" omitted.

Figure "Attachment 2, Keowee Hydro Station AC & DC Systems" omitted.

Figure "Attachment 3, 230KV Switchyard DC Power Distribution" omitted.

ATTACHMENT 4

SEQUENCE OF EVENTS

TIME DESCRIPTION

October 19, 1992

Keowee Unit 1 is generating to the grid

21:21:00 TN/5/A/2863/00/AL2, in progress.

US1 opens SY-1/SY-2 cross tie breaker

SY-2 bus voltage spikes in excess of 200 VDC

21:21:08 PCB-27, Breaker Failure (SBFU) relay actuated

PCB-24, SBFU relay actuated

SBFUs give YELLOW bus LOCK-out

PCB-24 SBFU initiates an ONS Unit 2 Generator Lockout.
N1 and N2 open

E1 and E2 close

SBFUs give RED bus LOCK-out

E1 and E2 open on under voltage when PCB-26 and 27 open

I&E Technician hears relays actuating.

US1 hears main steam relief valves lift.
(ONS Unit 1 stays On-Line because PCB-20 does not trip.)

ALL SWYD PCBs OPEN except PCB-11, 14, and 20

External Grid Protection initiates SWYD Isolation

ATTACHMENT 4

SEQUENCE OF EVENTS

TIME DESCRIPTION

SWYD Isolation gives Keowee Emerg. Start

ACB-1 opens for 6 seconds

ACB-5 and 6 open and ACB-7 and 8 close

SY-2 Charger de-energized by ONS 2 loss of power
Unit 2 RCPs, Condensate and Feedwater pumps trip.

Turbine Driven EFW Pump starts
CCW Gravity Flow starts

21:21:14 ACB-1 re-closes,
ACB-7 and 8 open and ACB-5 and 6 re-close.

KH Unit 2 energizes CT-4.
21:21:28 Main Feeder Bus Monitor Panel (MFBMP) times out
sends 2nd Emerg. Start to KH
initiates ONS Unit 2 Load Shed.

TDEFWP momentary loss of flow

SK1 and SK2 close

21:21:39 S1 and S2, close 10 seconds later
HPI A, HPI B, CC, MDEFW pumps all start

21:21:28 KO-A opens ACB-1
ACB-6 opens and ACB-8 fails to close
KH Unit 2 loses Auxiliary Power.
ACB-5, 7, and 1X Lockout

ATTACHMENT 4

SEQUENCE OF EVENTS

TIME DESCRIPTION

US1 recloses SY-1/SY-2 tie breaker

another surge on SY-2 causes SBFU to Lockout the

Keowee Main Step-up Transformer
Both KH Units spinning w/o Auxiliary power.

21:22 ONS-1 gets Low Inst Air Press. Alarm,
enters AP and has Diesel compressor started.

21:23 ROs note that RBCU A did not restart

21:25 ROs stop TDEFWP

21:26 ROs stop HPI A pump

ROs reset MFBMP/Load Shed Signal and begins recovery,

21:30 US3 calls Staff duty person, who initiates notifications

21:34 restart CCW pump (ends gravity flow)
2CCW-24 fails to reopen, Work Request initiated

KO-A calls Dispatcher, asks for call-out of KO-B
KO-A and US-2 talk, US-2 informed of KH problem
OSS talks to Dispatcher, starts SWYD recovery

21:50 KO-B arrives
KO-B, US-2, Dispatcher discuss situation

ATTACHMENT 4

SEQUENCE OF EVENTS

TIME DESCRIPTION

21:58 KO-B resets KH Main Step-Up Transformer Lockout.
ACB-1 closes, energizes Main Step-Up Transformer.
ACB-6 closes, restores Aux power to KH 2

22:00 US-1 resets RED, YELLOW lockouts

22:01 Dispatcher notifies LEE to start Gas Turbine, get
dedicated line

22:06 ACB-5 trip reset at breaker, allows ACB-7 to close

22:12 KO-B resets 1X Bus and ACB-7 Lockouts
KO-B manually closes ACB-7.

22:13 Operator closes PCB-10 ,energizes Red Bus
Reclosers close PCB-7, 13, 16, 19, and 22.

22:14 Operator tries to close PCB-26 which momentarily clears the Switchyard Isolate Complete Signal and the Anti-Pump Signal on PCB-9 which allows PCB-9 to auto close and energize Yellow Bus.

22:18 Operator resets the Switchyard Isolation Signal manually closes PCB-26 (energizes CT-2)

22:21 Lee CT/dedicated line operable

22:25 OSS declares Unusual Event

22:37 Unusual Event notifications complete

ATTACHMENT 4

SEQUENCE OF EVENTS

TIME DESCRIPTION

22:42 Operator resets KH Emergency Start Signal allows shutdown of KH 1

22:47 KOs inadvertent lockout of 1X, ACB-7 trips
Lockout reset, ACB-7 closed

22:52 KH-1 shut down, results in shutdown of KH-2 causes 2nd loss of power to ONS-2

MFBMP senses loss of voltage, 20 sec time out initiates Emerg Start of KH-1,2, Load Shed of ONS-2 this time ACB-6 opens, ACB-8 closes.

KH-1 emergency starts, but can't feed YELLOW bus (PCB-26 out of position, no SWYD Isol. signal)

KH-2 Field Breaker does not close due to Anti-Pump, the speed switch and the X-Relay.

EPSL re-energizes the Unit 2 MFBs from
CT-2 using the Re-transfer To Startup logic.

Operators manually initiate TDEFWP start.
CCW returns to gravity flow mode

22:54 Operator resets MFB Monitor Panel/Load Shed signals
and begins recovery.

ATTACHMENT 4

SEQUENCE OF EVENTS

TIME DESCRIPTION

October 20, 1992

00:18 Operator resets KH Emergency Start
shuts down KH 2,
RPMs drop, allowing the Field Breaker X-Relay to reset.

00:24 Operator starts KH 2 and energizes CT-4.

00:41 Operator energizes Yellow Bus from the Red Bus by closing
in PCB-8.

00:48- Operator closes PCB-18, 27, 30, 21, 17, 28, 12, and
00:57 15. This completes restoration of the 230 KV Switchyard.

01:14- Restart all Reactor Coolant Pumps.
02:29

01:25 Declare SSF degrade, retroactive to 21:21

03:44 Declare event terminated

04:15 restore SSF power, exit degrade

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DUKE POWER

November 18, 1992

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Subject: Oconee Nuclear Site
Docket Nos. 50-269, -270, -287
LER 270/92-04

Gentlemen:

Pursuant to 10 CFR 50.73 Sections (a) (1) and (d), attached is Licensee Event Report (LER) 270/92-04, concerning Loss of Off-site Power and Unit Trip due to Management Deficiency, Less Than Adequate Corrective Action Program.

This report is being submitted in accordance with 10 CFR 50.73 (a) (2)
(ii)
(C) and 10 CFR 50.73 (a) (2) (iv). This event is considered to be of no significance with respect to the health and safety of the public.

Very truly yours,

J. W. Hampton
Vice President
Oconee Nuclear Site

/lpp

Attachment

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ATTACHMENT 1 TO 9211230265 PAGE 2 OF 2

November 18, 1992
Page 2

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